

On NASA's 40th anniversary

A look at space propulsion of the past, present and future

by Deana Nunley and Tony Jacob

Space transportation and propulsion have arguably brought NASA its greatest triumphs during the agency's first 40 years. Today, scientists and engineers at the Marshall Center are working toward a similar burst of achievement focused not just at getting into space, but at dramatically lowering the costs of space travel to open the frontier for business and pleasure over the next 40 years.

When NASA was formed in 1958, the fledging space agency quickly found itself building on the early rocket and propulsion work of luminaries such as Robert Goddard and Wernher von Braun and his team of German rocket scientists.

Just more than a decade later, after an incredible burst in technology development and scientific achievement, Marshall-developed Saturn rockets boosted humans to the Moon. NASA and industry had, in a few short years, jumped from rudimentary engine designs to the development of the massive F-1 engine.

See *Propulsion* on page 4



Courtesy photo

This is an artist's concept of a magnetic levitation system used to launch an air-breathing rocket.

RD-180 test scheduled for today at Marshall

NASA engineers plan to test fire a Russian-built rocket engine Wednesday at approximately 4:30 p.m. CDT. The test will be conducted in the Advanced Engine Test Facility at the Marshall Center and is scheduled for 56 seconds.

The Marshall Center is under a Space Act Agreement with Lockheed Martin Astronautics of Denver to provide a series of test firings of the Atlas III propulsion system configured with the Russian-designed RD-180 engine.

Employees may watch the test from the viewing area north of the test stand and the area behind Building 4666.

Updates on the status of the RD-180 test may be obtained by calling 544-3375.

X-33 Linear Aerospike Engine undergoes powerpack tests at Stennis Space Center

by Tony Jacob

A critical milestone was achieved with the first successful powerpack test of the X-33's Linear Aerospike Engine at NASA's Stennis Space Center, Miss.

Engineers and technicians at Stennis conducted a successful 2.81-second powerpack test designed to calibrate the liquid hydrogen and liquid oxygen fuel turbopumps and test facility settings, as well as to verify valve timing to prime the gas generator.

This marks the beginning of a program to test engines leading to flights of the X-33 beginning next year. The X-33 technology demonstrator is being developed by the Lockheed Martin Skunk Works in Palmdale, Calif., under a cooperative agreement with NASA. It will

demonstrate technologies needed to develop a commercial reusable launch vehicle that will reduce the cost of launching payloads into space from \$10,000 to \$1,000 per pound.

The powerpack tested last night consists of the main power generating and pumping components of the aerospike engine, including liquid oxygen and liquid hydrogen turbopumps, a gas generator for the turbopump drive as well as vehicle connect lines and interconnecting flight ducts.

See *Aerospike Engine* on page 5

"Be smart, think safe"

Safety slogan submitted by
L.D. Stewart, EB14

Marshall tests flight antennas for X-33 launch vehicle

The Marshall Center has employed its world-class antenna test facilities to test the flight antennas for the X-33 launch vehicle, NASA's flagship technology demonstrator.

The tests were conducted this summer by personnel in the Radio Frequency Branch in Marshall's Astrionics Laboratory.

"Our job was to test each flight antenna before the contractor Lockheed Martin mounts it on the X-33," said Leon Bell, chief of the Radio Frequency Branch.

The wedge-shaped X-33 is a sub-scale technology demonstration prototype of a Reusable Launch Vehicle. It is being developed under a cooperative agreement between NASA and Lockheed Martin Skunk Works of Palmdale, Calif. The X-33 is a major assignment of the Space Transportation Programs Office at Marshall.

The X-33 will demonstrate key technologies and operational aspects of a Single-Stage Reusable Launch Vehicle (RLV) rocket system so as to reduce the risk to the private sector in developing a commercially viable system.

As part of the antenna testing at Marshall, four C-band and four S-band antennas were tested. Two C-band and two S-band antennas will be used on the vehicle and two C-Band and two S-Band antennas will

See Antennas on page 5



NASA photo by Terry Leibold

John Haynes of Marshall's Astrionics Laboratory conducts testing on the flight antennas for the X-33 technology demonstrator.



Courtesy photo

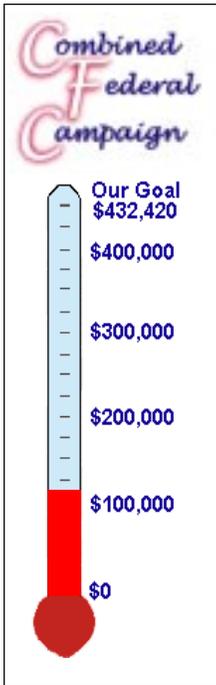
Marshall employees are Professional Development graduates

Four Marshall Center employees were among 21 graduates from eight NASA Centers to participate in the 1997-98 Professional Development Program. From left are NASA Administrator Dan Goldin, Marshall employees Scott Jackson, Nancy Gibson, Dorothy Hubbard and Tim Owen. The program provides competitively selected NASA professional personnel with developmental work assignments and a broader perspective of NASA and the impact of its programs on developing technology.

Ion propulsion to Deep Space launch planned

An October launch is planned for the first flight in NASA's New Millennium Program, designed to test and validate new technologies for science missions in the 21st century. A solar-powered, ion propulsion engine will provide the thrust for the first mission, Deep Space 1. It will be the first time in the history of space exploration for non-chemical propulsion to be used as the primary means of propelling a spacecraft. NASA Solar Electric Propulsion Technology Application Readiness — called NSTAR — will provide ion propulsion for Deep Space 1 on an 11-month mission that includes a flyby of an asteroid. NSTAR, managed by NASA's Jet Propulsion Laboratory in Pasadena, Calif., is part of the Advanced Space Transportation Program at the Marshall Center. The Jet Propulsion Laboratory and NASA's Lewis Research Center in Cleveland, Ohio, jointly built and delivered the NSTAR ion propulsion system. Launch of Deep Space 1 is scheduled for liftoff Oct. 25 aboard a Boeing Delta launch vehicle from Cape Canaveral Air Station, Fla.

Center pledges \$112,807 after first week of CFC



Marshall Center employee contributions during the first week of the 1998 Combined Federal Campaign (CFC) totaled \$112,807. The average gift per person is \$210.85 with 535 employees participating. Figures from 1997 show contributions after one week were \$81,302.24, and the average gift per person was \$189.95 with 428 employees participating.

“We are off to a terrific start,” said CFC chairperson Cathy Nichelson. “Not only have Center employees given more per person but the overall contributions continue to increase year after year.

“I feel privileged to be this year’s CFC chairperson and I will do my best to represent our Center and lead the campaign,” said Nichelson.

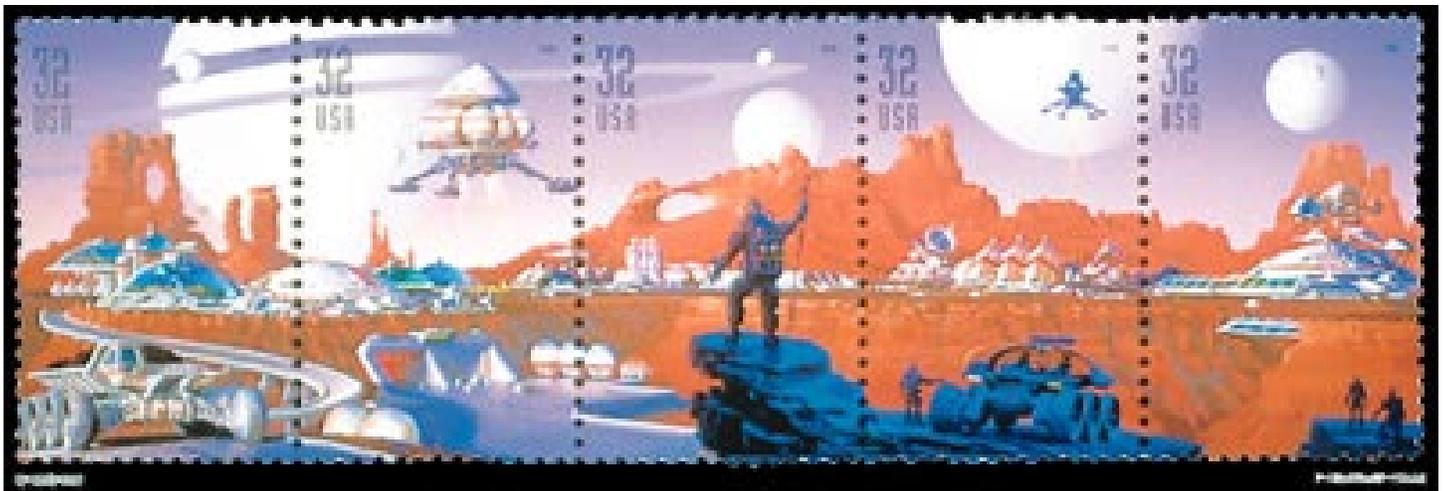
“Marshall employees are a wonderful group of people to work with and I know we will continue to lead the way in showing compassion and generosity.”

Organizations that have already wrapped up their campaign for the year include: BF01, BF70, CE01, CO40, CR90, JA01, JA02, JA10, MG10 and PP01.



NASA photo by Adline Byford

Marshall employee William “Chip” Dobbs has been honored with the “Humanitarian” award from the Huntsville Area Committee on Employment of People with Disabilities. Dobbs, who works as a general supply specialist in the Property Management Division of Marshall’s Logistics Services Office, received the award Oct. 7 for “demonstrating dedication to advancing the cause of persons with disabilities.”



Space discovery stamps featured during National Stamp Collecting Month

The post office in the basement of Bldg. 4200 has the new space stamp commemorating the theme for National Stamp Collecting Month — “Blast off into Discovery.” Designed by renowned aerospace artist Attila Hejja, the strip of five individual stamps come together to make up a futuristic scene, complete with space vehicles, space ships, a city and space explorers. Design elements also include hidden images which can be viewed only through a decoder lens, and the header of the stamps which appears to be floating off the pane. 185 million of the stamps have been printed and have been available in earthly post offices nationwide since Oct. 1.

Propulsion

Continued from page 1

The initial stage of the huge Saturn rocket was powered by five liquid-fueled F-1s, each producing 1.5 million pounds of thrust.

At the time of the first Saturn V launch, von Braun, then director of Marshall Center, said, "No single event since the formation of the Marshall Center in 1960 equals today's launch in significance. For MSFC employees – this is their finest hour."

Similar sentiments were expressed in the 1970s, when Marshall had a significant role in the development of the Space Shuttle and its propulsion systems. The Center continues to manage the Space Shuttle's propulsion elements, including the enormous solid rocket boosters and the super lightweight external tank.

The Space Shuttle Main Engine is considered by many to be the world's most sophisticated reusable rocket engine. The three liquid-fueled main engines

produce nearly one million pounds of thrust. The energy released by the three main engines at full power is the equivalent of 23 Hoover Dams.

Today, Marshall engineers are turning to cutting

edge technologies such as high-temperature ceramics and lightweight yet strong composites to design simpler, more innovative propulsion systems that will help NASA dramatically lower the costs associated with getting into space, and traveling in space.

Marshall engineers, for example, are designing what may be one of the world's simplest turbopump rocket engines. Only the second space launch engine developed in the United States in the last 25 years, the Fastrac engine has significantly fewer parts than previous engines.

The easy-to-build engine will initially cost approximately \$1.2 million to produce — about one-fifth of the cost of similar engines. The Fastrac provides

60,000 pounds of thrust to boost payloads weighing up to 500 pounds.

The first vehicle scheduled to be powered by the Fastrac engine is the X-34, a technology testbed vehicle to demonstrate key vehicle and operational technologies applicable to future low-cost reusable launch vehicles, or "space planes."

Another engine currently under development and component testing is the revolutionary linear aerospike engine, which will power NASA's X-33 Advanced Technology Demonstrator when it begins flight tests next year.

The X-33 is a half-scale technology demonstrator prototype of a reusable launch vehicle (RLV) Lockheed Martin has named "VentureStar®." Through ground research and demonstration flights scheduled to begin next year, the X-33 will prove the technologies needed for industry to proceed to the development of a full-scale RLV.

The linear aerospike features unique properties that include the ability to automatically compensate for altitude as the launch vehicle climbs, and also to steer the vehicle by varying the flow of

fuel from top to bottom and side to side. The engines are powered by J-2S-heritage turbopumps from the Saturn rocket.

Also, by burning a mix of liquid oxygen and liquid hydrogen, the byproduct of the X-33's engines will be super-hot steam, making the engines much more environmentally friendly than some traditional designs.

With the X-33 and X-34 technology demonstrators, NASA is demonstrating technologies required to reduce the cost of getting to space from today's costs of \$10,000 per pound to \$1,000 per pound.

At the same time, NASA's Advanced Space Transportation Program at the Marshall Center is building the highway to space by developing technologies focused

on the next level — reducing the cost of getting to space to only hundreds of dollars per pound.

"I think that 40 years from now traveling around in near-Earth orbit and to nearby planets will be a lot like air travel is today," said Garry Lyles, manager of the Advanced Space Transportation Program. "People will not think it's very unusual to hop on a spaceliner and go to a job on Mars or maybe even a month-long asteroid-mining mission."

Lyles expects a lot of people will be working and playing in space in 40 years. Human journeys to the outer planets and robotic probes to other star systems are also part of his vision for the 2040 timeframe.

"Propulsion systems for deep space missions of the future probably haven't even been thought of yet," said Lyles, "or if somebody's thought of them, they may be considered science fiction now."

Lyles says space transportation needs a technology breakthrough akin to the silicon chip that revolutionized the computer industry and made desktop computers commonplace. A technology breakthrough in propulsion coupled with a business venture that lures people to space will be the key to space development and travel to other star systems, he said.

"Breakthroughs don't just happen. Usually, a lot of work has preceded any breakthrough," said Lyles. "That's why the Advanced Space Transportation Program is doing technology work – even though we don't know what the right answer is.

"As long as we have a network of smart people working toward advancing propulsion for space transportation, I believe we'll have a breakthrough – and we'll accelerate the breakthrough through NASA's technology development."

NASA is studying a wide variety of propulsion technologies that could transform the vision to reality during the next 40 years of America's space program. Technologies currently being developed by the Marshall Center include air-breathing rocket engines, laser propulsion, magnetic levitation and antimatter.

"As long as we have a network of smart people working toward advancing propulsion for space transportation, I believe we'll have a breakthrough – and we'll accelerate the breakthrough through NASA's technology development."

– Garry Lyles, manager of the Advanced Space Transportation Program

Alabama A&M high school/ NASA day on Nov. 14

Volunteers are needed to share information about Marshall activities with high school students attending the annual high school senior/NASA Day football game between Alabama A&M and Alcorn State on Nov. 14. **Contact:** Efrem Hanson at 544-6340

Full Cost training to be held for Marshall employees

Full Cost training for Marshall employees will be held from 8 a.m.-4:30 p.m. Oct. 22 and Nov. 12 at the Sparkman Center on Martin Road, Bldg. 5304, room 4331/33; and Nov. 18 at the Sparkman Center in Bldg. 5304, room 4347/49. Employees may register for the eight-hour training via ADMINSTAR. **Contact:** Stephanie Elliott, 544-7553, Janie McCrary, 544-7552, Lisa Martin, 544-4374

Antennas

Continued from page 2

be used as spares, Bell said. The decision to test the flight antennas at Marshall was based in part on the experience the Center has had testing C-band tracking antennas that are used on the solid rocket boosters for the Space Shuttle, Bell said.

The tests involving the X-33 flight antennas were completed at the Marshall Center antenna range, located about one mile north of Marshall's von Braun Office Complex.

"This was a unique opportunity for us to test actual flight hardware," Bell said. "Most

of our testing involves engineering models."

Through demonstration flights and ground research, the X-33 program will provide the information needed for industry representatives such as Lockheed Martin to decide whether to proceed with the development of a full-scale Reusable Launch Vehicle Program.

The X-33 will take off vertically like a rocket, reaching an altitude of up to 60 miles and speeds between Mach 13 and 15 (13-15 times the speed of sound). It will land horizontally like an airplane. As many as 15 tests are planned to originate from Edwards Air Force Base, Calif., beginning in 1999.

'A Tuskegee Airman's Tale' topic of AIAA dinner program set for Oct. 22

On Oct. 22, the American Institute of Aeronautics and Astronautics (AIAA) will host a dinner program to hear "A Tuskegee Airman's Tale." Lt. Col. Herbert E. Carter (USAF, retired), will talk about his experiences as a fighter pilot in World War II. Carter is an original member of the 99th fighter squadron — the Tuskegee Airmen who were the first

black Army-Air Force squadron.

The program will be held at the Holiday Inn Research Park from 6 to 8 p.m. Tickets are \$18 each and seats should be reserved by Friday.

Contact: Tony Springer at 544-1571 (Tony.Springer@msfc.nasa.gov) or Tom Hancock at 961-4002 (Thomas.Hancock@hsv.boeing.com).

Aerospike Engine

Continued from page 1

Powerpack tests are critical in the development of the Linear Aerospike Engine because various performance levels can be tested in parallel with the engine fabrication and design. This individual component testing capability is one of the key benefits of the gas generator power cycle selected for X-33 application.

Full-scale engine tests are scheduled to occur at Stennis later in the year. Boeing's Rocketdyne Propulsion and Power Division builds the powerpacks and engines in Canoga Park, Calif.

"I commend the Rocketdyne-NASA team for achieving this milestone," said Gene Austin, NASA X-33 program manager from Marshall. "Getting hardware onto the test stands to verify its performance is just another sign of how well the X-33 development is progressing."

Steve Nunez, Stennis' X-33 project manager, added, "Appreciation goes to the combined Stennis Space Center and Rocketdyne test team for putting long hours into successfully completing this first critical test. They've done an outstanding job!"

Obituaries

Hamilton, Richard, 69, Decatur, Ala., died Sept. 17. Hamilton retired from Marshall in 1985 where he worked as an electronics engineer. He is survived by his wife Dorothy Hamilton.

Jacobs, Edwin, 63, Arab, Ala., died Sept. 14. Jacobs retired from Marshall in January where he worked as an aerospace engineer. He is survived by his wife Melba Jacobs.

Kinser, Thomas, 75, Fayetteville, Tenn., died Sept. 21. Kinser retired from Marshall in 1981 where he worked as an aerospace engineer. He is survived by his wife Freda Kinser.

McCarthy-Evans, Martha, 74, Moulton, Ala., died Sept. 22. McCarthy-Evans retired from Marshall in 1994 where she worked as a stenography secretary. She is survived by her husband Francis Evans.

Moore, William B., 57, Petersburg, Tenn., died Oct. 5. At the time of his death, Moore worked in air operations as Marshall's aircraft coordinator. He began working at Marshall on Dec. 6, 1961. Moore is survived by one brother, Ray Moore.



William Moore

Employee Ads

Miscellaneous

- ★ Crosby fishing boat, 15', w/25HP Johnson, trailer, \$950. 974-6644
- ★ Aquarium, 45-gallon, includes pumps, filters, lighted glass cover and custom wooden stand, \$150. 882-1566
- ★ Oak TV cabinet, double doors, swivel stand, two drawers, VCR shelf, \$365. 828-5303
- ★ Realistic Mach One, 160W speakers, \$120; NordicTrack Pro, \$250; Baldwin studio piano, \$1,500. 881-6962
- ★ Steel, 8X13' dog kennel, \$100. 881-0221
- ★ Antique dresser w/matching vanity, needs refinishing, \$125. 830-0866
- ★ 1969 Gibson hollow-body electric guitar, \$2,000 obo; crate amplifier, \$50. 461-4307
- ★ Steel bookcases, 3 and 4 adjustable shelves, gray, \$15 each; tan, \$20 and \$25 each. 881-6040
- ★ Evenflo infant car seat, "On My Way," navy/white stripe, \$40. 536-7502
- ★ Hay, bermuda or mixed grass, square bales, fertilized, \$2.50 per bale. 778-8830
- ★ Super single daybed/waterbed, dark oak, 3 under-bed storage drawers, lighted bookcase headboard, \$150. 837-2122
- ★ Crystal perfume bottles, plain/\$35, painted/\$45; Russian wood burst box, \$25. 882-6832
- ★ Electric hand drill, 1/4", \$10; fertilizer spreader, \$5; men's three suiter luggage, \$15; 3-speed bicycle, \$75. 881-8648
- ★ Set of wheels for 1995 Ford F150 truck, gray, lug nuts, center caps, \$300. 883-9741.
- ★ Sears free-standing wood heater, burnished brown, glass doors, blower includes pipes, wood, \$300. 837-6776
- ★ Auburn vs Florida football tickets, one pair (together) at regular price. 233-0705
- ★ 486DX120 PC minitower, 24/540MB, CDROM, SVGA monitor, voice/fax modem, Internet ready, manuals, \$325. 461-8721
- ★ Cabinet with 2-15" Black Widow speakers; 1970 Chevrolet gas tank, six 14" Chevy rims, 837-0621
- ★ 16' tandem axle trailer. 233-5533
- ★ Kingsize waterbed, \$100; Broyhill dresser and two night tables, \$200. 852-8256
- ★ Recliner, chair, burgundy w/black, beige, and blue stripes, stanguard protected fabric, \$275. 828-3373
- ★ 1988 Dynatrak fish and ski boat, 17.5 feet, \$4,200. 784-9099
- ★ U.S. divers fins, mask, snorkel, weight belt and weights, and other dive gear. 881-0557
- ★ Dining room table, maple, Mediterranean, leaf, 4 chairs and lighted china cabinet, \$400. 880-3063

Vehicles

- ★ 1991 34' Airstream trailer, many options,

\$24,500; 1989 Ford diesel clubwagon, \$8,500. 881-9421

- ★ 1992 Ford Taurus, GL, \$4,000 obo. 852-3298
- ★ 1974 Volkswagon Beetle, \$2,495. 851-0893
- ★ 1993 S-10 Tahoe pickup, 5-speed, A/C, AM/FM cassette, bedliner, black, 97K miles. 586-2213
- ★ 1995 Ford Windstar GL, dual a/c, cruise, pw/pl, tow package, 70K miles, \$10,100. 859-4156
- ★ 1995 Chrysler New Yorker, maroon w/gray interior, Infinity stereo, 60K miles, \$10,300. 880-9025
- ★ 1986 Toyota Celica GT, 64K miles, a/c, 5-speed, AM/FM cassette, cruise, \$3,450. 881-8970
- ★ 1996 Dodge Neon highline, 38K miles, \$6,700 firm. 586-7246
- ★ 1988 Honda Accord, A/C, automatic, 129K miles, \$3,300; 1988 Jeep Commanchee, 5-speed, A/C, 150K miles, \$3,300. 721-7377
- ★ 1995 Grand Voyager, V-6, dual air, 58K miles, \$8,750. 464-6624

Found

- ★ Huntsville Times umbrella, left outside mailroom in Bldg. 4200 on Oct. 7. 544-5187

Wanted

- ★ Huntsville Times newspaper, August, 11, 12, 13, and 14, 1998. 539-2951
- ★ 7' pool table in excellent condition. 852-9617

Center Announcements

- ★ **MARS Ballroom Dance Club** — The MARS Ballroom Dance Club Formal Fall Dinner Dance will be held in the Von Braun Center West Hall on Oct. 17 and will feature ballroom music by the Paul Chambers Combo. Socializing will begin at 6:30 p.m., and dinner will be served at 7 p.m., followed by dancing until 11 p.m. Tickets are available until noon today at \$18 each with a \$3 discount for members. **Contact:** Tamara Landers at 544-6818, Pat Sage at 544-5427, Ed Ogozalek at 837-1486, Linda Kinney at 544-0563 or Bob Williams at 544-3998.
- ★ **AIAA** — The American Institute of Aeronautics and Astronautics' 1998 Defense and Space Programs Conference is scheduled Oct. 28-30 at the Von Braun Center. Admission is paid for all Marshall civil service employees with NASA/MSFC badges required for admittance. See the October calendar of the AIAA home page at: <http://www/aiaa.org/>
- ★ **Skylab Reunion** — The 25th Annual Skylab Reunion will be held from 6-10 p.m. Nov. 13 at Johnson Space Center, Houston, Texas. Ticket cost is \$17 per person and checks may be made payable and sent to: Skylab Reunion, NASA/Johnson Space Center, Bldg. 1, Houston, TX 77058-3696. Include name for identification tags and address and telephone number. The deadline for purchasing

tickets is Oct. 31. For more information, call (281) 244-1998 or e-mail to: skylab.reunion@jsc.nasa.gov

- ★ **Alabama A&M University Lecture** — Alabama A&M University will host the first Putch Venkateswara Memorial Lecture at 3 p.m. Fri., Oct. 23, in Dawson Auditorium at Alabama A&M. A reception will be held at 5 p.m. in the West Campus Reception Area. Dr. Robert Curl of Rice University, recipient of the 1996 Nobel Prize in chemistry, will speak. **Contact:** Prof. Ravi Lal at 858-8148 or Jerome Saintjones at 858-4863
- ★ **Blue Cross/Blue Shield** — The Federal representative from Blue Cross will be at the Marshall Center from 9-11 a.m., Oct. 15 in Bldg. 4200, room 324 to assist employees with questions and claims problems.
- ★ **Las Vegas Trip** — Executive Tour & Travel Service, Inc., through the NASA Exchange at Marshall is offering a Las Vegas Great Escape for only \$169 per person, based on double occupancy. The offer includes a 4-day/-night hotel and entertainment package at the Stardust, the Riviera or the Sahara Resort and Casino; round trip transfers to and from McCarran International Airport for two people; daily two-for-one buffet meals; two-for-one admission to live shows, plus much more. A deposit of \$145 by Oct. 30 is required. **Contact:** Executive Tour & Travel at 1-800-272-4707. The NASA Exchange account reference is ER11583-003 and is available to Marshall employees, retirees and on-site contractors.
- ★ **Shuttle Buddies** — The Shuttle Buddies will meet for breakfast at 9:15 a.m. Oct. 26 at Shoney's on University Drive West. **Contact:** Deemer Self, 881-7757
- ★ **NARFE** — The National Association of Retired Federal Employees (NARFE), will meet at 9:30 a.m., Oct. 17, at the Senior Center on Drake Ave. U.S. Rep. Bud Cramer will be available to answer questions. **Contact:** 837-0382 or 881-3168
- ★ **Lunar Nooners** — The NASA Lunar Nooners Toastmasters Club will meet at 11:30 a.m. on Oct. 20, in the 4610 cafeteria conference room. **Contact:** Lee Johns, 544-5142.
- ★ **Quality Lab Reunion** — The second reunion luncheon of the Quality Laboratory will be held on 11 a.m. Nov. 12 at the Redstone Officers Club. Reservations are required. **Contact:** Frank Batty, 536-9187, Art Carr, 881-8432, Dick Henritze, 534-8312 or P.M. Hughes, 881-1937.
- ★ **Genealogical Computing Society** — The Huntsville Genealogical Computing Society will meet at 7 p.m. on Oct. 19 at the Main Library. Call 881-6670 for more information.

Job Opportunity

CPP99-3-PL, General Engineer, GS-801-15, S&E, Mission Operations Laboratory, Office of the Director. Closes Nov. 2.

MARSHALL STAR

Marshall Space Flight Center, Alabama 35812

The Marshall Star is published every Wednesday by the Internal Relations and Communications Office at the George C. Marshall Space Flight Center, National Aeronautics and Space Administration. Contributions should be submitted no later than Friday noon to the Marshall Internal Relations and Communications Office (CO40), Bldg. 4200, room 101. Submissions should be written legibly and include the originator's name. Send electronic mail submissions to: ann.bryk@msfc.nasa.gov The Marshall Star does not publish commercial advertising of any kind.

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